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Design and Fabrication of Arduino Based Flexible Manufacturing Process on the Desk: 3D Printing

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Abstract: Rapid prototyping technology also referred to as additive manufacturing or 3D printing, which can be used to create physical objects from geometrical representation by successive addition of materials in layer-by-layer form. 3D printing technology is the fastest emerging technology used to make work easier. It can be used in a wide range of materials such as PLA, ABS, HIPS & composite. 3D printing is a rapidly growing and very perfectly cost optimized form of rapid prototyping. 3D printing technology is appreciable in future challenges for mass production. This type of printing is anticipated to influence the industries like Medical, Education, Equipment, Automation, consumer Products and various businesses. The process adopted by us is FDM technology, in which different materials like ABS (Acrylonitrile Butadiene Styrene), PLA (Polylactic Acid), HIPS (High Impact Polystyrene), etc. By heating any of the filament material to its melting point, it is deposited layer by layer.

Combining many layers of such a type will give us a final 3D model. This project explains the layout, improvement and production of a 3D printing system which could produce a high give up fine product at a completely low price. This 3-D printing project can be used in various fields like Rapid Prototyping, instructional zone, residence-keep printing purposes, industrial 3D Printing offerings and retailers.

Keywords: 3D printing, FDM, AM, Rapid Prototyping, ABS

I. INTRODUCTION

3D printing or additive production is a method of creating 3 dimensional strong items from a digital file. The creation of a 3-D printed object is performed using additive procedures. In an additive procedure an item is created by means of laying down successive layers of material until the entire object is created. Each of these layers may be seen as a thinly sliced horizontal move-segment of the eventual object. Additive Manufacturing technologies facilitate the fabrication of elements and devices which can be geometrically complicated, have graded fabric compositions, and may be custom designed for design and production of cell structures. Every product development technique involving an additive manufacturing device calls for the operator to undergo a hard and fast collection of obligations. Easy-to- use “personal” 3-D printing machines emphasize the simplicity of this venture collection. W. Kuczko. [1] Developed a method to compute deformation and stresses in the built parts by FDM by considering critical processing variables. Y. Zhang and K. Chou[2] developed a finite element model to analyze the distortions and stress distribution at different processing conditions through central composite design (CCD) and analysis of variance ANOVA technique. It became concluded that layer thickness was the main issue affecting the residual stress and distortion in FDM manufactured components. 3D printing plays a vital role in cloud-based manufacturing which is related to service oriented to configure select and utilize the resources. 3D printers are used for two main purposes, for rapid manufacturing and also rapid prototyping. There are various methods for 3D printing the objects such Standard Tessellation Language (STL).

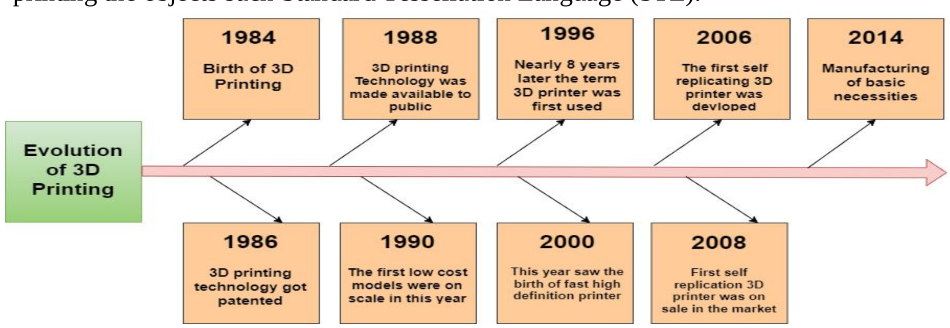

Figure No: 1.1 History of 3D Printing

In general, 3D printers are used for two purposes: Rapid prototyping (creating prototypes for traditional manufacturing with proper accuracy and research purposes) and rapid manufacturing (creating products for short run custom manufacturing). There are several strategies for printing 3D gadgets. A short description for these techniques is proven in underneath where the primary concepts for every printing approach are mentioned

II. 3D PRINTING METHOD

1) *Fused Deposition Modelling (FDM):* This technique in particular works on melting a thermoplastic fabric using a resistive heater and extruding the molten material through nozzle in step with the statistics provided to the printer. The first layer very speedy hardens as it sticks to the warmth mattress and next layer stick with the preceding one.
2) *Stereolithography (SLA):* A laser beam is used with proper orientation to harden photopolymer resins and thus produce solid objects.
3) *Laser Sintering / Laser Melting:* A laser is traced out to a powdered fabric which reasons the powder particles to be fused. This approach ought to be performed in a totally sealed chamber of inert fuel and at a particular temperature.
4) *Selective Deposition Lamination (SDL):* In this manner an adhesive with exclusive densities is fed to offer the function of bonding layers of paper together. The cross sections of object can have higher densities and others with decrease densities are used as supports. After that the printing plate movements as much as a heated plate and strain is implemented. Finally each layer is reduce through an adjustable Tungsten carbide blade. Colourful gadgets can be produced by this technique.
5) *Material Jetting:* Works by means of selectively jetting the printing fabric which is typically in molten or liquid country and supporting material through distinctive jetting heads. However, the printing substances tend to be liquid photopolymers, so curing manner is wanted to provoke a chemical polymerization reaction which reasons the plastic to dry and form a strong.
6) *Binder Jetting:* Initially a powder is feed by the piston after that an automated roller spreads the powder equally on the build platform. Finally the print heads applies binder to the cross sections that form the final object.

III.METHODOLOGY

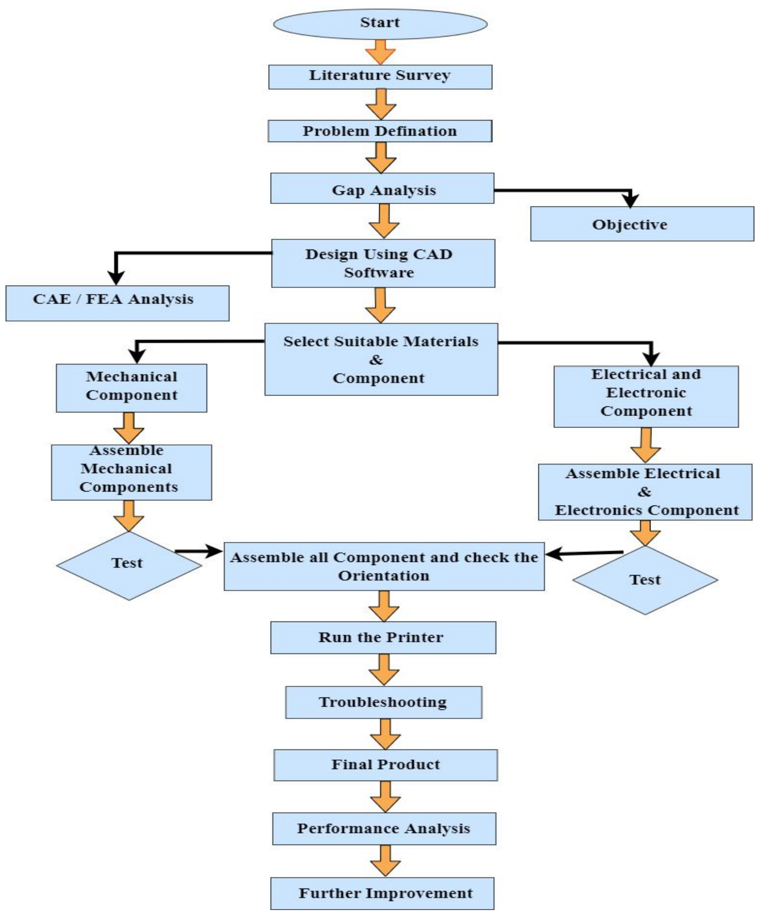

Figure No: 3.1 Working Methodology of Project Work

We have started with finding solutions for cost and accuracy and researched different types of 3D printing methods and its process than selected the proper mechanism for our printer. Then started the literature survey and find out some serious gaps which are required to be filled with orientation and mechanism of 3d printer. Afterwards we designed our printer in CAD Modeling software. We used solid works and prepared proper dimensions and completed our design. Then moved to selection of different types of mechanical as well as electrical components for our 3d printer on the basis of our design and requirement of output from our 3d printer, Afterwards we assembled all electrical and mechanical components and fabricated our printer, then started the programming using Arduino IDE Software and uploaded the marlin programming with our own specifications & sent it to Arduino Mega 2560 and then started our printer with the help of Printrun software and successfully manufactured different components.

IV. DESIGN OF THE 3D PRINTER

In this section, we have discussed the 3D printer aim & mechanism of Printer design.

A. Aim of Design

A figure 3 shows the three axis of movement: X, Y, and Z in which Z is middle X and Y for (back and forth movement). This mechanism makes use of five stepper motor, two for Z-axis motion in (Vertical motion), one for Y-axis (back and forth movement), one for X-axis motion in right to left in (Horizontal motion) and one for extruder filament. This mechanism uses two motors to control the lead screws to which the print bed is connected in vertical motion with a Z-path. Two motors have been used right here due to the fact the print quantity is big; there could be a disruption in the motion if a handiest unmarried motor is used. The conceptual layout has been to begin with visualized in Sketch-up software program.

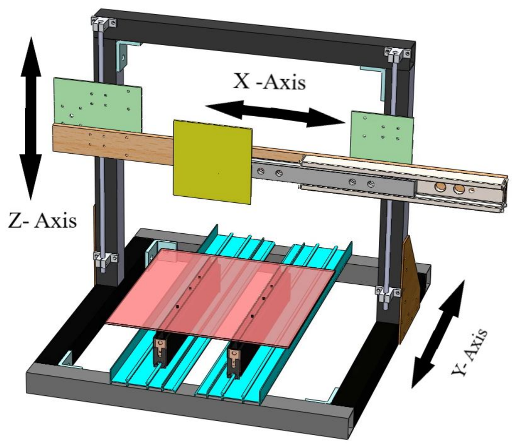

Figure No: 4.1 CAD Model of 3D Printer with X, Y and Z Movement

B. Selection of Mechanism in 3D Printer

A 3D Printer CAD mechanism shows in figure 3 a first thing which is very important is a orientation of frame at which all movements are to be carried out in X, Y and Z direction. The Slider HotEnd moves left to right in (X-direction) with the help of GT2 timing belt and pulley mechanism. The Z - axis moves in vertically with Z-direction along with X -direction with the help of lead screw and two stepper motor. The build platform moves in (back and forth movement).

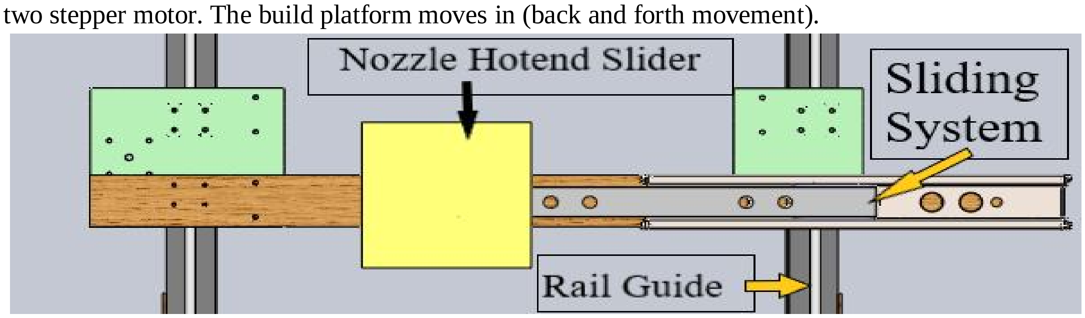

Figure No: 4.2 X-Axis Cad Design

Currently mechanisms such as, for example, Cartesian, SCARA, Polar Delta and so on are utilized as a part of the development of FDM 3D Printers. We select the Cartesian-type mechanism arrangement for development, where the bed moves in the vertical direction then the extruder moves at X Direction (Horizontally) and Z moves the up or down. Z hub development on such a 3D printer is extremely exact and requires low increasing speed; however the bed should be less weight with a specific end goal to look after precision, which makes it harder to include the completely programmed bed leveling framework.

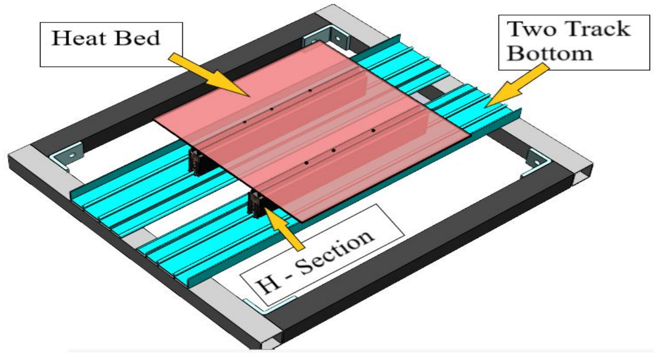

Figure No: 4.3 Y-Axis Cad Design

Controlling a straight Cartesian type mechanism framework like this is mechanically straight and furthermore generally simple from a product point of view, which is the reason most 3D printers available in the market utilize this kind of plan. The Cartesian Type mechanism arrangement of frameworks has for quite some time been utilized for instruments like CNC processing machines, plotters and 2D printers.

1) Cartesian Configuration

Cartesian 3-D printers are quite much named after the coordinate gadget the X Y and Z axis that's used to determine wherein and a way to flow in three dimensions and the Cartesian 3D printers which have a heated mattress which moves handiest inside the Z axis. The extruder sits at the X-axis and Y-axis, in which it may move in 4 guidelines on a gantry. This is the principle which may be seen in action on the models from Ultimaker and MakerBot [3].

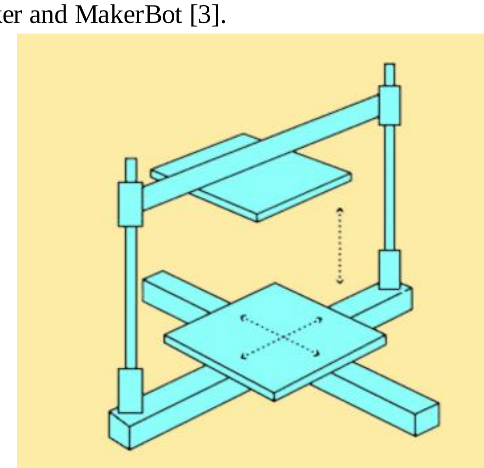

Figure No: 4.4 Cartesian Configurations

V. MATERIAL USED IN FDM 3D PRINTING

1) *PLA:* PLA (Polylactic Acid) is one of the most commonly used 3D printing materials (other than ABS). It is the ‘default’ recommended material for many 3D printers, and with specific good reason - PLA is useful in a widest range of printing applications, has the virtue of both odorless and low warp and requirement of heat bed will not be necessary. PLA is also one of the eco-friendlier and recyclable 3D printer materials available; it is made from annually renewable resources (corn-starch) and requires less energy to process compared to traditional (petroleum-based) plastics.

- Nozzle Temp: - 180 - 225°C
- Bed Temp: - 30 - 60°C

2) *BS:* ABS (Acrylonitrile Butadiene Styrene) commonly used 3D printing material. Made from petroleum, ABS is usually utilized in injection moulding. Best used for making long lasting components that needs to face up to higher temperatures. Less proof towards heat and chemical substances. If we differentiate PLA with ABS than plastic is less brittle. It can also be post-processed with acetone to offer a smooth end.
- Nozzle Temp: - 225-240℃
- Bed Temp: - 80-125℃

3) *Nylon (Polyamide):* Nylon is an effectively strong, durable, and versatile 3D printing material. It is very Flexible when it is thin but it is a higher-level layer adhesion and the nylon lends itself well to things like the living hinges and the different functional parts. Nylon filament prints as a bright natural to white with a translucent surface and can absorb color addition post process with most common, acid-based clothing dyes
- Nozzle temp: - 230-275℃
- Bed Temp: - 65-85℃

4) *LAYBRICK:* LAYBRICK is a 3D printing material that gives parts the look of gray stone while retaining the resiliency of plastic, making it ideal for architectural designs. The print will come out mostly smoothly, whereas with higher temperatures it will begin to have more pitted, sandstone-like textures. Careful with LAYBRICS because it will fracture easily.
- Nozzle Temp: - 165-210℃
- Bed Temp: - 60-70℃ (No heat bed required, but if used then maintain)

VI. FIRMWARE'S AND SOFTWARE'S

The firmware is utilized to read only memory (ROM) in non- volatile memory in computer programs that are used to control the devices in hardware.

A. Marlin

Marlin was firstly introduced in 2011for RepRap and Ultimaker by Erik Van Der Zalm. Marlin is an open-source Firmware. Marlin supports a wide range of varieties of 3D printers, including the Arduino and Ramps. It coordinates the sensors, light, LCD display, heater with stepper motors including everything related to 3D printers. Marlin control derives the G-codes; the main function of G-code is to command the machines like "rotate the stepper motor at 130°. Marlin is also used for advanced temperature & motion control for high precision tuning and operates with filament run out and power loss recovery.

B. Cura

Cura is slicing software developed by David Brram in the year 2014 for slicing purposes, later it was taken over by Ultimaker. Cura slices the CAD 3D models & translates the 3D STL., OBJ into your printer can read the formats. In easy language, Cura generates the commands for 3D printers. Worldwide there are different 3D printers, as every printer has its own specification or setup like, size of nozzle, print area, and size of heating plates. Slicing software needs to identify these hardware details in the printer profile.
Some special features of Cura

1) Cura provide the different view models (Solid, X-Ray and Layers)
2) To Control overall print quality like wall thickness control with finish and durability.
3) Control infill pattern for time and material consumption. Some important patterns are Line, Grid, Triangle, Cubic, and Concentric, Concentric 3D and Zigzag.
4) Cura can control the speed along with the speed of infill.
5) Many 3D models are overhang; Cura provides the automatically supported structure for models.

C. Pronterface

Pronterface is open-source software and it is quicker and easier. It was created by the RepRap initiative. Pronterface used for a long time & it is part of Printrun Suit for managing & controlling the 3D printer and CNC machine.
Pronterface is a simple and graphical user interface that provides detailed analysis to you to monitor and control the printer with the help of USB connections.

With the help of a Pronterface you can test all the technical components manually or automatically for example after successfully connecting the printer is able to move the axis with the help of stepper motor, nozzle or heat bed temperature. In short, Pronterface is utilized for enabling and disabling stepper motors, switching the End stop, switching peripherals, moving to specific position, extruding specific length of material filament, reporting saved configuration settings. Pronterface can handle the G-Code & STL files.

VII. CONCLUSION AND FUTURE SCOPE

1) A consumer based totally product became advanced according with the product layout and prototyping procedure. The product being rapid prototyping machine which is beneficial in small stage packages like academic, family & studies purposes.
2) The one-of-a-kind concepts generated to address the problem and declaration had been discovered to be fruitful. For a few issues, mixtures of the principles had been used, like changing the temperature of particular layers.
3) The project has helped to recognize integration of different electronic and mechanical systems and its importance.
4) Product development from concept to testing has led to imposing layouts for manufacturing and assembly.

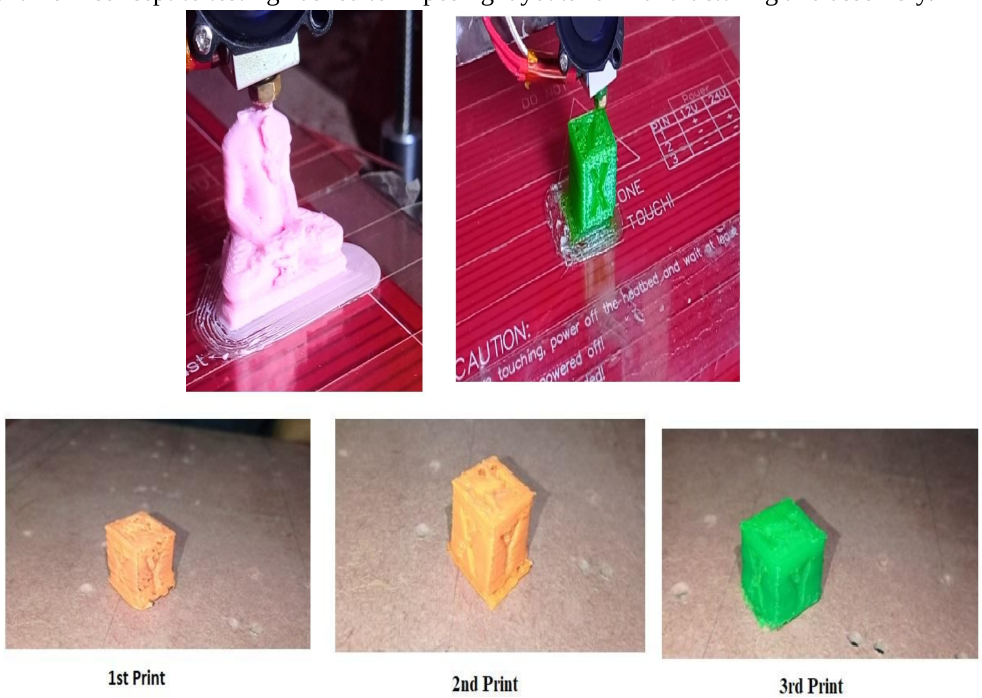

Figure No: 7.1 Final Manufactured Parts

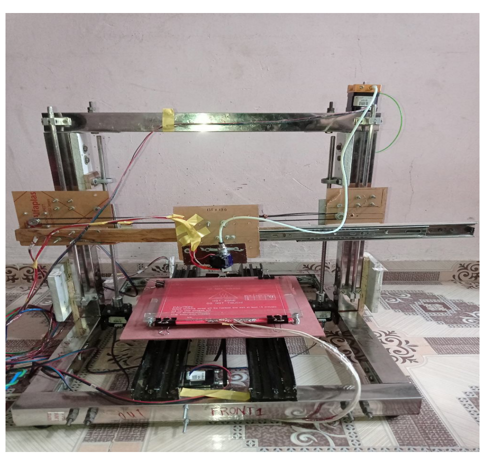

Figure No: 7.2 Final Fabricated Working model

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Table No- 7.1 Technical Specification of Our Printer

SPECIFICATIONS	
Technology	Fused Filament Fabrication (FFF)
Machine Dimensions (x*y*z mm)	524 *620 *460
Build Volume (x*y*z mm)	300 * 300 *200
Weight (KG)	8 Kg
Chassis/Body Material	Stainless Steel
Minimum Layer height (microns)	50
No. of Extruders	1
Nozzle Diameter (mm)	0.4
Print Material(s)	PLA, ABS, Flexible, T Glass, Wood
Filament Diameter (mm)	1.75
Power Consumption (Watts)	72
Connectivity	USB, SD Card
Software	Cura, Ultimaker Cura, Pronterface and Slicer
OS	Windows, Mac
File Types	STL, G-code

The Arduino based 3-D printer has an open structure. Thus, surrounding temperature would have had a effect on the build layers. During the fabrication process the effect of ambient cooling was not controlled or measured. These could be controlled and studied in future research. We can add more easy sliding system in place of chrome plated rod to make mechanism smother and easy to run. There is no such requirement of hard chassis for your machine with steel, aluminum or any other metal you can use wood as well for your chassis if you are using it for your household uses.

A. Aerospace Industry

3D printing technology provides unparalleled freedom in design in component and production. In the aerospace industry, 3D printing technology has potential to make improved and complex geometries, lightweight components, which can reduce energy resources and recruitments. 3D printing technology can lead to fuel savings because it can reduce the material or component weight to produce aviation related components.

B. Automotive Industry

Currently, 3D printing technology has extremely rapidly changed our industry to develop, design and manufacture various products. In the automobile industry, 3D Printing techniques have improved impressively to provide new shines, allowing for lighter and more complex structures in very less time. For instance, Local vehicle industries printed the first 3D-printed electric car in 2014. Not only cars, Local Motors also extended the broader ranges of application of 3D printing technology by manufacturing a 3D-printed bus called OLLI. OLLI is a driverless, electric, recyclable and smart 3D printed bus.

C. Food Industry

3D printing technology opens the doors not only for the industries, but also for the food industry. At present there is an increasing demand for the customization and development of food for specialized dietary needs, such as athletes, children, pregnant woman, patient and so on which requires a different amount of nutrients by reducing the amount of unnecessary ingredients and enhancing the presence of healthy ingredients. By using 3D printing technology, particular materials can be mixed and processed into various complicated structures and shapes. Chocolate, sugar, pureed food and flat food such as pizza, pasta and crackers can be used to create new food items with intricate and attractive designs and shapes. 3D printing technology is a high energy efficiency technology for food production with environmentally friendly, good quality control and low cost.

D. Healthcare and Medical Industry

3D printing technology can be used to print 3D drug and pharmaceutical research, skin bone and cartilage, replacement tissues, organs, printing for cancer research and models for visualization, education, and communication. There are various different advantages of 3D Printing technology for biomedical products which are:

1) 3D printing technology can replicate the natural structure of the skin with a cheaper cost. 3D printed skin can be used to test chemical products, pharmaceuticals and cosmetics. Hence no need to use animal skin for testing the products [4].
2) 3D printing technology is utilized to replace, restore, maintain, or improve the tissues' function. The replacement tissues produced by 3D printing technology have the interconnected pore network, biocompatible, appropriate surface chemistry and has good mechanical properties [5].

E. Architecture, Building, and Construction Industry

3D printing technology can be considered as an environmentally friendly derivative and it gives unlimited possibilities for geometric insolubility realization. In the construction industry, 3D printing technology can be used to print overall buildings or can create construction components. The emergence of Building Information Modelling (BIM) will facilitate good use of 3D printing technology. Building Information Modelling is a digital representation of functional and physical characteristics, and can share information and knowledge about 3D building. It can form a reliable source for decision during its life cycle, from initial conception to demolition for construct or design the building [6].

F. Electric and Electronic Industry

The production process for the 3D electrode by using the FDM 3D printing technique provides a cheaper cost and a time efficient approach to mass producing electrode materials. Compared to commercial electrodes such as copper, carbon and aluminum electrodes, the design and surface area of the 3D electrode can be easily customized to suitable particular applications.

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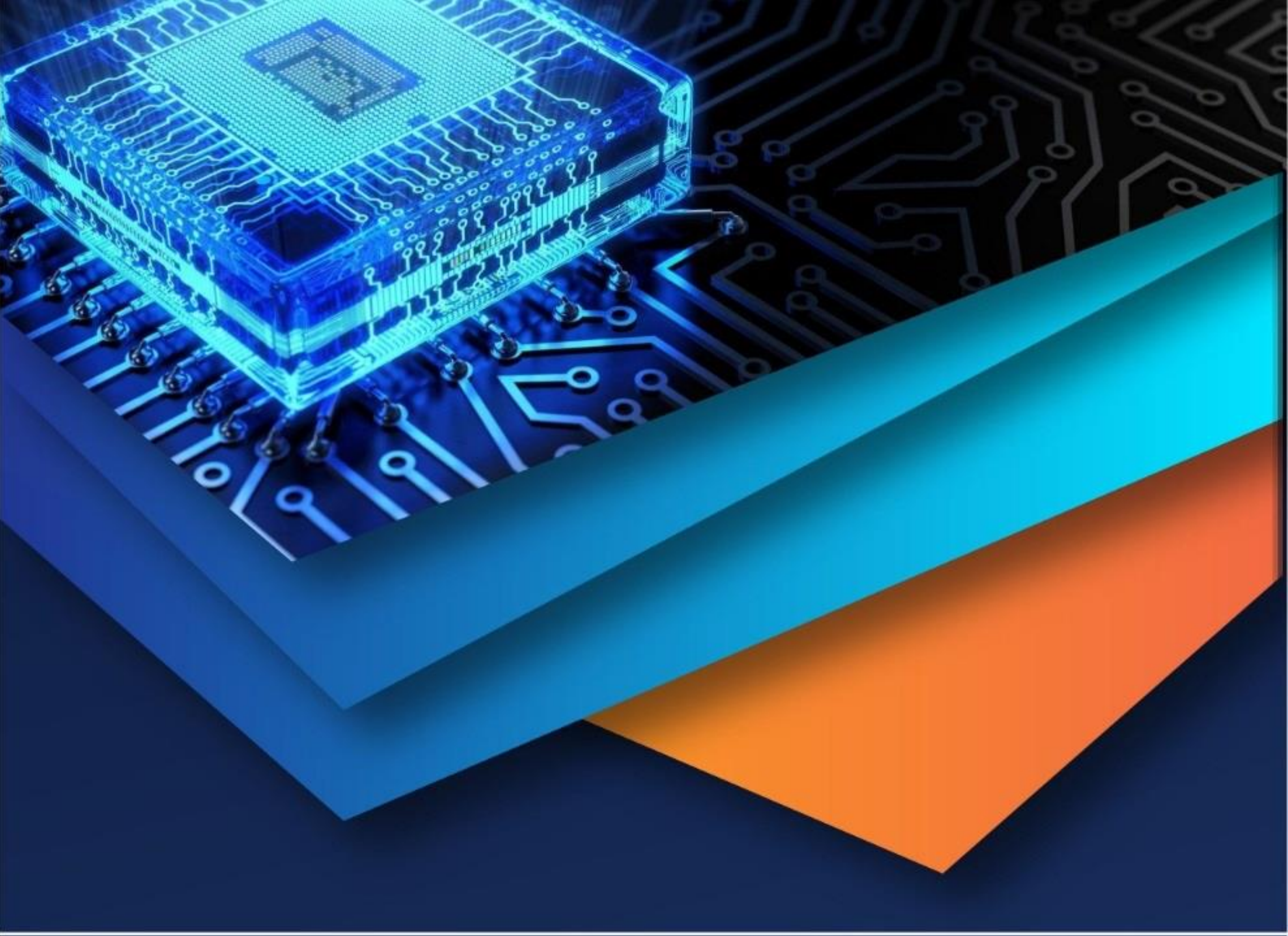

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